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Method for processing workpiece surfaces

The invention relates to a method for processing workpiece surfaces which are to be supplied with lubricant when the workpiece is in use.

A method of the generic type has been closed by DE 43 16 012 C2. In this case, recesses preferably running crosswise relative to one another are incorporated in the workpiece surface by means of laser jets. In particular when applying this method in the case of cylinder running surfaces, however, it is disadvantageous that the lubricant does not remain in the recesses during the movement of the piston but rather is pushed out of said recesses by the piston rings, in particular because all the recesses of the workpiece surface communicate with one another. The result of this is that the lubricant is usually not at the location where it is required for the lubrication, a factor which during said application leads to a high oil consumption and therefore to poorer emission values. A further disadvantage of the known method is its relatively high costs and the requisite rework.

The object of the present invention is therefore to provide a method for processing workpiece surfaces which are to be supplied with lubricant when the workpiece is in use, by means of which method optimum supply of lubricant to the workpiece surface can be ensured.

This object is achieved according to the invention by the features mentioned in claim 1.

By capillaries being incorporated according to the

invention in the workpiece surface by means of high-pressure water jets, individual recesses are obtained in said workpiece surface, into which recesses the lubricant can penetrate without being delivered from the workpiece during a relative movement in which the workpiece participates. This is because the capillaries are recesses which do not communicate with one another, so that a certain amount of lubricant always remains in them. Thus micro pressure chambers form which have the effect of minimizing friction power and friction wear under tribological stress.

The capillaries which are produced by the high-pressure water jets may occur, for example, in the form of plastic deformations in the steel structure or in the form of released graphite flakes.

The use of high-pressure water jets for roughening surfaces has been disclosed in principle by DE 101 53 305 A1. This is a cost-effective and reliable method.

By the method according to the invention, the capillaries can in each case be advantageously provided in those regions of the workpiece surface to be processed where a lubricant supply is necessary, whereas the remaining part of the surface, in particular the part between a top and a bottom dead center, can be finished with as small a surface roughness as possible. On account of the high piston speed prevailing there, hydrodynamic lubrication is also effected with a lower lubricant quantity.

If, in an advantageous development, a cylinder liner of an internal combustion engine is used as workpiece to be machined, friction and wear and also oil consumption and emissions of the internal combustion engine can be

reduced by the optimization according to the invention of the tribological properties of the cylinder running surface.

If provision is made in this connection for the capillaries to be incorporated in a region directly below the top dead center of a piston moving relative to the cylinder running surface, an especially good supply of lubricant to that region which is subjected to the greatest loading, in particular the greatest thermal loading, during operation of the internal combustion engine is obtained, whereas the central region of the cylinder running surface need not be processed and therefore has a lubricating film of lower height, a factor which can considerably reduce the oil consumption of the internal combustion engine.

Furthermore, provision may be made for the capillaries to be incorporated in a region directly above the bottom dead center of a piston moving relative to the cylinder running surface. What has been stated with regard to the top dead center applies in principle to this measure, with the difference that the region of the bottom dead center is subjected to less pronounced thermal loading.

Further advantageous configurations and developments of the invention follow from the remaining subclaims. An exemplary embodiment of the invention is explained in principle below. In the drawing:

fig. 1 shows a device for carrying out the method according to the invention;

fig. 2 shows a cylinder running surface processed by means of the method according to the invention;

fig. 3 shows a view of the cylinder running surface according to arrow III from fig. 2; and

fig. 4 shows the profile of the thickness of the lubricating film between the top dead center and the bottom dead center of a piston moving relative to a cylinder running surface.

Fig. 1 shows, in a highly schematic illustration, an internal combustion engine 1 having a crankcase 2 in which a cylinder liner 3a forming a workpiece 3 to be processed is arranged in a known manner. Of the workpiece 3, its workpiece surface 4, that is to say the cylinder running surface 4a in the present case, is to be processed, to be precise in order to improve the supply of lubricant, for example oil, to the cylinder liner 3a during the use of the latter.

To this end, a device 5 is moved into the workpiece 3, that is to say into the bore of the cylinder liner 3a in the present case, this device 5 having a lance 6 which is provided with a plurality of high-pressure nozzles 7. One to eight high-pressure nozzles 7 are preferably arranged around the periphery of the lance 6, high-pressure jets 8 being discharged in the direction of the workpiece 3 via said high-pressure nozzles 7. In particular in the case of workpieces 3 of a different kind, an even larger number of high-pressure nozzles 7 would be conceivable, which if need be could also be arranged in a plurality of planes.

Since the high-pressure water jets 8, depending on the material of the workpiece 3, are discharged at a pressure of 1800 to 3200 bar, they remove portions of the material

from the workpiece 3, so that a microstructure in the form of individual capillaries 9 is incorporated in the workpiece surface 4, the shape and dimensioning of which capillaries 9 will be dealt with in more detail later.

As shown, the high-pressure water jets 8 are preferably continuously delivered in a horizontal plane, that is to say 90° to the longitudinal axis 6. During the processing, the lance 6 is rotated at 10 to 1000 rev/min, in particular 100 to 500 rev/min. Furthermore, the following parameters have proved to be practicable when using aluminum or an aluminum alloy for the workpiece 3: a pressure of the high-pressure water jets 8 of 2800 to 3200 bar at a water flow rate of 10 to 20 l/min or alternatively a pressure of the high-pressure water jets 8 of 1800 to 2200 bar at a water flow rate of 25 to 45 l/min, a feed of the lance 6 of 5 to 12 mm/min and a distance of the high-pressure jets 7 from the workpiece surface 4 of 10 to 15 mm.

If gray cast iron, a gray cast iron alloy or steel is used as parent material for the workpiece 3, a pressure of the high-pressure water jets 8 of 2800 to 3200 bar at a water flow rate of 10 to 20 l/min or a pressure of the high-pressure water jets 8 of 1800 to 2200 bar at a water flow rate of 25 to 45 l/min may likewise be used. In contrast to aluminum, however, the feed of the lance 6 should merely be 0.5 to 5 mm/min, and the distance of the high-pressure nozzles 7 from the workpiece surface 4 may likewise be 10 to 15 mm.

Figures 2 and 3 show the cylinder liner 3a processed by means of the high-pressure water jets 8 and examples of the form of the incorporated capillaries 9. The capillaries 9, which are arranged according to a

stochastic distribution, preferably have a ratio of their width b to their depth t within the range of 1:2 to 1:10. If the material used for the workpiece 3 is an aluminum alloy, their diameter or their width b is 10 to 20 μm and their depth t is on average around 60 μm. In contrast, the diameter or the width b of the capillaries 9 is within a range of 40 to 60 μm and the depth t is on average around 120 μm if the material used for the workpiece 3 is gray cast iron or steel. The form and size of the capillaries 9 can be influenced to a certain extent by the abovementioned parameters. For example, the capillaries 9 can be incorporated in the workpiece surface 4 in the form of channels, holes or trough-shaped recesses. In the view according to fig. 3, it can be seen that the capillaries 9 are in each case not connected to one another irrespective of their form.

Especially when processing cylinder running surfaces 4a, it would be appropriate to incorporate the capillaries 9 in a region directly below a top dead center TDC of a piston 10 moving relative to the cylinder running surface 4a and in a region directly above a bottom dead center BDC of the piston 10. The region in which the capillaries 9 are incorporated may be, for example, in each case 10 to 15% of the distance between the top dead center TDC and the bottom dead center BDC. In this way, the lubricant, preferably oil, remains in particular in the region of the reversal points of the piston 10 when the cylinder liner 3a is in use, so that, especially in these regions subjected to both high mechanical and thermal loading, improved lubricant supply is provided for, which contributes to a lower oil consumption and therefore also to lower emissions of the internal combustion engine 1. Owing to the fact that the capillaries 9 are in each case not connected to one another irrespective of their form,

the piston 10 cannot distribute the lubricant between the capillaries 9, so that the capillaries 9 ideally serve as lubricant pockets or lubricant reservoirs and thus can form a pressure cushion together with the tribological partner, in this case the piston 10. This ensures a uniform distribution of the lubricant in the regions in question.

This can also be seen in the diagram according to fig. 4, in which the lubricant distribution, that is to say the profile of the thickness of the lubricating film, is plotted against the path of the piston 10 between the bottom dead center BDC and the top dead center TDC of the cylinder running surface 4a. Here, the broken line shows the distribution according to the prior art, where it can be seen that the greatest lubricant quantity is located in the central region, whereas there is very little lubricant at the two dead centers BDC and TDC. However, by the method according to invention, as shown by the solid line, good lubricant supply is achieved especially in the region of the two dead centers TDC and BDC.

Instead of being applied in the case of the cylinder running surface 4a, the method described may also be applied, for example, in the case of camshaft or crankshaft bearings or in the case of other workpiece surfaces 4 which are to be supplied with lubricant when the workpiece 3 is in use.